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Profile of Problem-Solving Ability and Mathematical Creativity of Pre-Service Teachers: A Review Based on Matlin's Cognitive Framework

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Abstract
Problem-solving ability and mathematical creativity are two key competencies that mathematics teachers must possess to facilitate effective learning in schools. This study aims to describe the profile of problem-solving ability and mathematical creativity of pre-service mathematics teachers and to examine the relationship between these two variables through Matlin's cognitive framework. A quantitative descriptive-correlational approach was employed with 30 third-semester mathematics education students selected via purposive sampling. Instruments included a Polya-based problem-solving test, an open-ended mathematical creativity test based on fluency, flexibility, originality, and elaboration indicators, and semi-structured interviews. Results show that problem-solving ability was at a moderate level (mean = 11.47; SD = 3.12), with the highest achievement on problem comprehension (80.8%) and the lowest on looking-back (60.0%). Mathematical creativity was also moderate (mean = 10.33; SD = 3.28), with fluency highest (76.7%) and originality lowest (55.8%). Interview analysis revealed cognitive barriers including mental set, functional fixedness, and math anxiety among lower-category students. Pearson correlation yielded $r = 0.741$ ($p < .05$), indicating a strong positive relationship. Findings are discussed through Matlin's information-processing model, connecting both abilities via rich associative networks and spreading activation. Implications include recommendations for developing pre-service teachers' pedagogical repertoire through problem-based learning and open-ended tasks.

Keywords: problem solving; mathematical creativity; pre-service teacher; Matlin; metacognition

INTRODUCTION

21st-century education positions higher-order thinking skills (HOTS) as a core competence for students, encompassing critical, creative, communicative, and collaborative thinking[1]. Within the context of mathematics education, problem-solving skills and mathematical creativity emerge as the two most crucial abilities[2]. The Kurikulum Merdeka (Independent Curriculum) explicitly positions problem-solving as the primary objective of mathematics instruction, while embedding creativity within the Profil Pelajar Pancasila (Pancasila Student Profile) to be systematically cultivated through the educational process [3].

While these competencies are fundamentally aimed at secondary school students, the effectiveness of their development relies directly on the quality of the instructing teachers. Competent mathematics educators must not only master the subject matter but also possess the capacity to

[1] Sepriyanti et al., 'The Effect of 21st-Century Learning on Higher-Order Thinking Skills (HOTS) and Numerical Literacy of Science Students in Indonesia Based on Gender'.
[2] Nilimaa, 'New Examination Approach for Real-World Creativity and Problem-Solving Skills in Mathematics'.
[3] Ru'yatul Hidayah and Sari, 'The Influence of the Pancasila Student Profile Strengthening Project in Mathematics Learning on the Merdeka Curriculum on Students' Problem-Solving Skills'.

effectively facilitate problem-solving and foster creativity among their students. Consequently, higher education institutions play a highly strategic role; mathematics education students, as pre-service teachers, serve as a vital bridge connecting pedagogical theory taught in universities with actual practice in school classrooms [4].

Empirical evidence indicates that many mathematics teachers still encounter significant difficulties in teaching problem-solving and creativity, a challenge largely attributed to inadequate preparation during their undergraduate studies[5]. If pre-service teachers are not habituated to confronting non-routine problems and engaging in creative thinking, they will struggle to facilitate the development of these essential skills in their future students. Consequently, analyzing the problem-solving and creative abilities of pre-service mathematics teachers constitutes an urgent and strategic area of investigation.

Matlin, in her seminal work Cognition, provides a highly relevant cognitive framework for understanding both constructs [6]. Problem-solving is defined as a cognitive process that occurs when an individual attempts to attain a goal that cannot be reached through routine procedures. In this process, cognitive barriers such as a mental set (the tendency to rely exclusively on previously used strategies) and functional fixedness (the tendency to perceive a concept through a singular function) serve as primary impediments. Conversely, creativity is intrinsically linked to divergent thinking—the capacity to generate numerous potential solutions to a single problem—which encompasses four core indicators: fluency, flexibility, originality, and elaboration.

Prior research indicates that undergraduate students' problem-solving and creative abilities remain sub-optimal. Jailani et. al. found that the majority of students performed poorly on HOTS-based tasks [7]. Furthermore, Zhan et. al. demonstrated that procedural instruction hinders creativity[8], while Weiss and Wilhelm observed that students exhibited low levels of flexibility and originality [9]. Although Franz et. al. confirmed a positive correlation between creativity and problem-solving skills, studies that systematically integrate Matlin's cognitive framework into profiling pre-service teachers remain scarce [10].

This study aims to: (1) delineate the problem-solving proficiency profile of pre-service teachers based on Polya's framework; (2) describe the profile of mathematical creativity based on Matlin's divergent thinking indicators; and (3) analyze the correlation between these two dimensions. The findings are expected to offer valuable insights for teacher education programs in designing a more comprehensive and robust preparation curriculum for prospective mathematics educators.

LITERATURE REVIEW

Problem-Solving Ability from Matlin's Cognitive Perspective

Problem-solving ability is a core competency in mathematics education, defined as an individual's capacity to understand a problem, devise a strategy, execute the plan, and evaluate the final solution [11]. The National Council of Teachers of Mathematics (NCTM, 2000) positions problem solving as one of the five core process standards in mathematics learning, alongside reasoning, communication, connection, and representation.

Matlin classifies problems into three distinct categories: (1) well-defined problems, which feature clear procedures and explicit goals; (2) ill-defined problems, which lack a definitive procedure and are closely akin to open-ended tasks; and (3) transformation problems, which require

[4] Olawale, 'Impact of Pre-Service Teacher Education Programme on Mathematics Student Teachers' Teaching Practices during School Experiences'.

[5] Ling and Mahmud, 'Challenges of Teachers When Teaching Sentence-Based Mathematics Problem-Solving Skills'.

[6] Matlin, *Cognition, 8th Edition*.

[7] Jailani, Sugiman, and Apino, 'Implementing the Problem-Based Learning in Order to Improve the Students' HOTS and Characters'.

[8] Zhan, He, and Zhong, 'How Does Problem-Solving Pedagogy Affect Creativity? A Meta-Analysis of Empirical Studies'.

[9] Weiss and Wilhelm, 'Is Flexibility More than Fluency and Originality?'

[10] Franz, Fackler, and Paetsch, 'Profiles of Pre-Service Teachers' Personality Traits and Cognitive Abilities: Relations with Graduation and Teacher Self-Efficacy'.

[11] Barana, Boetti, and Marchisio, 'Self-Assessment in the Development of Mathematical Problem-Solving Skills'.

transitioning from an initial state to a goal state through a series of steps. Non-routine mathematical problem-solving typically falls under the scope of ill-defined and transformation problems[12]. Furthermore, Matlin identifies four cognitive strategies: algorithms (procedures that guarantee a solution), heuristics (general strategies that increase the probability of finding a solution), analogies (leveraging structural similarities to previously solved problems), and means-ends analysis (minimizing the gap between the current state and the goal state). These four strategies correspond directly to Polya's problem-solving steps.

Matlin’s conceptualization of metacognition comprises three essential components: metacognitive knowledge (knowledge about one’s own cognitive processes), metacognitive monitoring (real-time awareness of the ongoing cognitive process), and metacognitive control (the capacity to adjust strategies based on monitoring results). The metacognitive monitoring component is directly relevant to Polya’s "looking back" phase, which has consistently emerged as the weakest indicator in the current study [13].

Mathematical Creativity as Divergent Thinking

Mathematical creativity is defined as the capacity to generate novel ideas, strategies, or solutions within a mathematical context. Guilford distinguishes divergent thinking from convergent thinking; divergent thinking produces multiple potential responses from a single stimulus, whereas convergent thinking converges on a single, unique correct answer[14]. The four indicators of mathematical creativity—fluency, flexibility, originality, and elaboration—represent the operationalization of divergent thinking within the mathematical domain.

Matlin also elucidates the cognitive barriers that impede creativity [15]. Functional fixedness refers to the tendency to perceive a concept only through its conventional function, thereby hindering the exploration of alternative approaches. A mental set is the inclination to repeatedly apply a previously successful strategy without considering its appropriateness for a novel problem. These two cognitive obstacles align with empirical findings indicating that undergraduate students struggle with flexibility and originality indicators. Furthermore, the concept of insight (the sudden understanding that occurs after a period of incubation) and Wallas’s stages of creativity (preparation, incubation, illumination, and verification) provide a comprehensive account of how creative solutions emerge.

The Relationship Between Problem-Solving and Creativity

Matlin explains the interplay between problem-solving and creativity through an integrated information-processing model[16]. When confronting non-routine problems, individuals simultaneously activate: divergent thinking to generate a pool of candidate strategies, convergent thinking to evaluate and select the optimal strategy, and metacognitive monitoring to ensure the process proceeds accurately. The cognitive foundations of both constructs are fundamentally identical, rooted in the richness of associative networks within long-term memory and the capacity for spreading activation, which allows a single concept to activate related concepts. Empirically, Evans et. al. confirmed that mathematical creativity exerts a positive influence on students' non-routine problem-solving performance [17].

METHOD

Research Design and Participants

This study employed a quantitative approach with a descriptive-correlational research design. The descriptive method was utilized to delineate the profiles of problem-solving ability and mathematical creativity among pre-service teachers, while the correlational analysis was applied to determine the relationship between these two variables. The research participants comprised 30 third-

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[12] Matlin, *Cognition, 8th Edition*.
[13] Noviyana et al., ‘Enhancing Elementary Students’ Mathematical Problem-Solving Skills Through AI-Assisted Problem-Based Learning’.
[14] Guilford and Vaughan, ‘Factors That Aid and Hinder Creativity’.
[15] Matlin, *Cognition, 8th Edition*.
[16] Matlin.
[17] Evans et al., ‘Non-Routine Mathematical Problem-Solving: Creativity, Engagement, and Intuition of STEM Tertiary Students’.

semester undergraduate students from the Mathematics Education Study Program, selected via purposive sampling.

The selection of third-semester students was based on the consideration that they had already acquired the relevant foundational mathematics knowledge. Following the administration of the tests, six students were selected for semi-structured interviews based on their performance categories: two from the high-ability category, two from the medium-ability category, and two from the low-ability category. Data triangulation between the test results and interview responses was conducted to obtain a more comprehensive overview of the students' cognitive processes.

Research Instruments

Three distinct instruments were deployed in this study. First, the problem-solving test consisted of four non-routine tasks based on Systems of Linear Equations in Two Variables (SLETV)[18]. Each task was designed to measure one of Polya's problem-solving indicators[19]: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back. Each item was scored on a scale of 1–4, yielding a maximum total score of 16.

Second, the mathematical creativity test comprised four open-ended tasks based on SLETV, with each item measuring a specific indicator of mathematical creativity: fluency (generating variations of SLETV models), flexibility (solving problems using diverse methods), originality (constructing unique word problems), and elaboration (explaining solutions in detail). Each question was scored on a scale of 1–4, with a maximum total score of 16. Third, a semi-structured interview guide containing 32 questions was utilized to deeply explore the students' thinking processes, cognitive barriers, and metacognition.

Data Analysis Techniques

The data were analyzed using two statistical techniques. Descriptive analysis involved calculating the mean, median, mode, standard deviation, variance, and category distribution (High: 13–16, Medium: 9–12, Low: 4–8). Correlational analysis utilized the Pearson product-moment correlation test to evaluate the presence, strength, and direction of the relationship between problem-solving ability and mathematical creativity. Meanwhile, the qualitative interview data were analyzed using Matlin's cognitive framework.

RESULTS AND DISCUSSION

Profile of Problem-Solving Ability

The results of the problem-solving test from the 30 pre-service teachers are presented in Table 1. The mean score of 11.47 out of a maximum score of 16 indicates that, generally, the students demonstrated a moderate level of proficiency. However, the standard deviation of 3.12 points to a fairly wide variation in ability among the participants.

Table 1. Descriptive Statistics of Problem-Solving Ability

Statistics	Value
Mean	11.47
Median	12.00
Mode	12
Standard Deviation	3.12
Variance	9.74
Maximum Score	16
Minimum Score	4
Range	12

The categorical distribution of the students' problem-solving ability is outlined in Table 2. Nearly half of the students (46.7%) fell into the medium category. Meanwhile, 30.0% reached the high category, and 23.3% remained in the low category.

[18] Feige and Reichman, 'On Systems of Linear Equations with Two Variables per Equation'.

[19] Maulyda et al., 'Problem-Solving Ability of Primary School Teachers Based on Polya's Method in Mataram City'.

Table 2. Categorical Distribution of Problem-Solving Ability

Category	Score Range	Frequency	Percentage (%)
High	13 – 16	9	30.0
Medium	9 – 12	14	46.7
Low	4 – 8	7	23.3
Total	—	30	100.0

The attainment rate across Polya's indicators reveals a significant downward trend, as detailed in Table 3. The "understanding the problem" indicator yielded the highest attainment (80.8%), whereas "looking back" emerged as the weakest dimension (60.0%).

Table 3. Attainment per Polya Indicator

Polya Indicator	Mean	Attainment (%)	Classification
Understanding the Problem	3.23	80.8	Good
Devising a Plan	2.97	74.2	Fair
Carrying Out the Plan	2.87	71.7	Fair
Looking Back	2.40	60.0	Fair

This downward pattern in the attainment of Polya's indicators closely aligns with Matlin's (2009) conceptualization of metacognition. The stage of understanding the problem merely requires encoding and information representation from the text. Conversely, looking back demands the highest level of metacognitive monitoring—where students must actively question whether their process was correct and whether the results are plausible. The weakness in this indicator confirms the findings of Kelly et. al., which stated that students encounter substantial difficulties during the final solution evaluation stage [20].

Analysis of student responses across categories revealed distinctive cognitive patterns. Low-category students (represented by subject S1) encountered failures during the problem representation phase within Matlin's framework—meaning they were unable to transform verbal information into symbolic mathematical models. For instance, in Item 1 (the SLETV task regarding notebooks and pens), S1 wrote '2+3=21,000' without assigning variables, demonstrating a clear failure in propositional representation. In Item 2, S1 applied a mental set involving an irrelevant averaging strategy for the SLETV task, reflecting negative transfer in Matlin's terminology.

Medium-category students (represented by subject S2) generally demonstrated sufficient declarative knowledge but exhibited execution errors in their procedural knowledge. The most prominent phenomenon among these students was the failure to detect structural anomalies. For example, when the elimination method resulted in y = 3,428.57 (a non-integer value for a discrete object), S2 did not question the real-world plausibility of this value and proceeded with the calculation. Matlin[21] explains this as weak plausibility checking—a critical component of metacognitive monitoring that should actively verify whether an answer is reasonable within the problem's context.

High-category students (represented by subject S3) displayed a well-structured problem-solving process consistent with Matlin's framework. They did not merely know which method to use, but also understood why it was selected. S3 consistently employed two different methods (elimination and substitution) as a form of self-verification, reflecting mature cognitive flexibility and metacognitive awareness. This ability to explain the "why" behind each procedural step is precisely the competency most needed by pre-service teachers to foster conceptual understanding in their future classrooms, rather than merely teaching rote procedures.

Profile of Mathematical Creativity

The results of the mathematical creativity test are presented in Table 4. The mean creativity score (10.33) was noticeably lower than the mean problem-solving score (11.47). This discrepancy aligns with Matlin's assertion that divergent thinking requires specialized cognitive practice that differs from convergent thinking, which is generally more dominant in conventional education.

Table 4. Descriptive Statistics of Mathematical Creativity

Statistics	Value
Mean	10.33

[20] Kelly, McLoughlin, and Finlayson, 'Analysing Student Written Solutions to Investigate If Problem-Solving Processes Are Evident Throughout'.
[21] Matlin, *Cognition, 8th Edition*.

Median	10.50
Mode	12
Standard Deviation	3.28
Variance	10.74
Maximum Score	15
Minimum Score	4
Range	11

Based on the descriptive statistics presented in Table 4, the pre-service teachers' mathematical creativity scores exhibit a considerable spread, as evidenced by a standard deviation of 3.28 and a variance of 10.74. Although the median score (10.50) sits slightly above the empirical mean (10.33), the wide gap between the maximum score (15) and the minimum score (4) underscores the highly heterogeneous nature of the students' creative capacities. This high variability indicates that while a small fraction of pre-service teachers has naturally developed adequate divergent thinking skills, a substantial proportion still encounters severe cognitive blocks when required to venture beyond conventional algorithmic procedures.

Table 5. Categorical Distribution of Mathematical Creativity

Category	Score Range	Frequency	Percentage (%)
High	13 – 16	7	23.3
Medium	9 – 12	15	50.0
Low	4 – 8	8	26.7
Total	—	30	100.0

To provide a more granular insight into this variability, the categorical distribution in Table 5 reveals that exactly half of the participants (50.0%) are concentrated within the medium creativity tier. While 23.3% of the students successfully reached the high-performance category, a concerning 26.7% remained trapped in the low-capacity bracket. The fact that more than a quarter of these future educators exhibit low mathematical creativity poses a critical pedagogical challenge. According to professional teaching standards, teachers with underdeveloped creative faculties are highly likely to struggle in designing open-ended mathematical tasks or facilitating innovative, non-routine discussions in their future classrooms.

Table 6. Attainment per Mathematical Creativity Indicator

Indicator	Mean	Attainment (%)	Classification
Fluency	3.07	76.7	Fair
Flexibility	2.70	67.5	Fair
Originality	2.23	55.8	Low
Elaboration	2.33	58.3	Fair

The attainment pattern of the creativity indicators followed a hierarchical sequence: Fluency (76.7%) > Flexibility (67.5%) > Elaboration (58.3%) > Originality (55.8%). This sequence is highly consistent with Matlin's theory, which states that the ease of generating ideas (fluency) develops earlier than the capacity to alter cognitive approaches (flexibility). Meanwhile, originality represents the highest tier of creativity, requiring deep insight and mental restructuring.

An indicator-specific analysis revealed distinct cognitive barriers. In the Fluency task, medium-category students (S2) constructed four distinct models, yet each model consisted of only a single equation rather than an actual SLETV system. This denotes a schema error in Matlin's terminology—the students' mental schema regarding SLETV was structurally inaccurate, resulting in partial fluency. In the Flexibility task, low-category students (S1) utilized only a single method despite the prompt explicitly requesting at least two. This confirms the presence of functional fixedness: students were locked into a single approach due to a rigid mental set toward whichever method (elimination or substitution) they had first mastered.

The originality indicator yielded the lowest overall attainment (55.8%). Low-category students designed a word problem themed around toy rentals but tried to solve it using an invalid averaging strategy—demonstrating that originality in problem posing was not accompanied by adequate procedural mastery. Matlin explains that authentic creativity requires a balanced integration of novelty (originality of ideas) and appropriateness (accuracy of execution). This imbalance presents a distinct challenge for pre-service teachers, who need to learn how to design tasks that are both highly creative and pedagogically sound.

Conversely, high-category students on the Originality task created a cafe-themed problem featuring menus tailored for both human visitors and their pet cats—a highly unique and novel context. More importantly, the problem was meticulously designed using backward planning: the students predetermined a realistic mathematical solution first, and then systematically constructed the system of equations that would yield that exact solution. This reflects mature mathematical creativity—creativity that is inextricably linked with mathematical precision.

Interview Findings: Metacognition Profile

The semi-structured interviews conducted with six students (two per category) provided a profound, qualitative overview of their metacognition that was not captured by the written tests. High-category students exhibited mature metacognitive knowledge: they knew precisely when to utilize elimination versus substitution, were fully aware of the limitations of each method, and possessed reliable backup strategies. A representative statement from this group was:

"*I look at the coefficients first; if they can be immediately eliminated, it's more efficient. But I still check using substitution just to be sure.*"

Matlin refers to this type of awareness as conditional knowledge—knowing not only 'what' and 'how' but also 'when' and 'why' a specific strategy should be deployed.

Medium-category students, on the other hand, demonstrated a noticeable gap between metacognitive knowledge (knowing the appropriate method) and metacognitive monitoring (insufficient vigilance during procedural execution). A typical response from this group was:

"I already knew I wanted to use elimination, but sometimes midway through, the numbers got messy and I didn't realize it."

Another compelling finding emerged when they were asked if they knew alternative methods; most answered affirmatively but admitted they were simply not habituated to exploring them. This indicates that low flexibility is often driven not by a lack of conceptual knowledge, but rather by weak intrinsic motivation to cognitively explore—an affective factor that written instruments fail to capture.

Low-category students revealed a significant presence of math anxiety:

"When the problem is difficult, my mind goes blank, and I completely lose my concentration."

Matlin explains that math anxiety directly disrupts working memory capacity by generating intrusive worry thoughts that consume active processing space [22]. This condition establishes a vicious cycle: anxiety impairs performance, and the resulting failure further reinforces the anxiety. Low-category students also demonstrated an acute overreliance on examples—meaning they were only capable of solving tasks identical to the examples previously modeled by instructors, a direct consequence of rote memorization without deep understanding.

These interview findings have serious structural implications for teacher education programs. Pre-service teachers who experience unaddressed math anxiety are highly likely to transmit this anxiety to their future students through rigid, highly procedural teaching styles that are intolerant of student exploration. Matlin emphasizes that a learning environment that supports autonomy and minimizes heavy evaluative pressure is an absolute prerequisite for the optimal development of creativity and problem-solving skills.

The Relationship Between Problem-Solving and Creativity

The results of the Pearson product-moment correlation test are presented in Table 7. The obtained r-value of 0.741 falls within the strong correlation category based on Guilford's interpretation scale (0.60–0.80). The significance value of $p = 0.000$ is well below $\alpha = 0.05$, confirming a highly statistically significant relationship.

Table 7. Results of the Pearson Correlation Test

Variable	Mean	SD	Pearson r	Sig.	Interpretation
Problem-Solving	11.47	3.12	741	0.000	Strong, Significant
Mathematical Creativity	10.33	3.28	—	—	—

The strong correlation between problem-solving and creativity can be elucidated through Matlin's integrated information-processing model [23]. When confronting non-routine tasks, individuals simultaneously activate three distinct cognitive processes: (1) accurate problem representation to build an appropriate mental model; (2) flexible strategy selection to choose effectively among various

[22] Matlin.
[23] Matlin.

approaches; and (3) continuous metacognitive monitoring to ensure the process runs accurately. These three processes inextricably involve both problem-solving ability and creativity as unified constructs.

The precise mechanism underlying this correlation is explained by Matlin through the concepts of rich associative networks and spreading activation. Robust problem-solving skills are built upon a rich network of interconnected knowledge within long-term memory. This identical network enables spreading activation—a process where the activation of one mathematical concept triggers the activation of surrounding, related concepts—which serves as the underlying cognitive mechanism behind fluency and flexibility in creativity. This finding strongly aligns with research by Evans et. al.[24] and Kalban[25] which confirmed a positive correlation between divergent thinking and non-routine problem-solving skills.

The practical implications of these findings are highly significant for curriculum design. Instructional frameworks engineered to enhance non-routine problem-solving ability will automatically support the simultaneous development of mathematical creativity, and vice versa. Consequently, teacher education programs do not require two separate, isolated intervention tracks; rather, a single, holistic, and exploration-based pedagogical approach is sufficient to develop both core competencies required by future educators at once.

CONCLUSION

In conclusion, this study yields three pivotal insights into the cognitive and creative architecture of pre-service mathematics teachers. First, the problem-solving proficiency of these future educators predominantly resides within the moderate domain (mean=11.47; 46.7% in the medium tier), characterized by a robust capability in understanding the problem (80.8%) but a severe cognitive bottleneck during the looking back phase (60.0%). This pronounced deficiency in validation highlights a critical deficit in metacognitive monitoring within Matlin's theoretical framework, indicating that students frequently execute calculations without active evaluative vigilance. Second, their mathematical creativity similarly settles in the moderate category (mean=10.33; 50.0% in the medium tier), revealing a stark disparity between proficient fluency (76.7%) and deficient originality (55.8%). This depressed originality is heavily driven by cognitive impediments such as functional fixedness and rigid mental sets, while qualitative insights further unmasked the covert role of math anxiety as a debilitating affective barrier that consumes active working memory capacity but remains entirely undetected by standardized written metrics.

Third, a highly significant and robust positive correlation was established between problem-solving proficiency and mathematical creativity ($r=0.741$, $p<0.05$). Viewed through Matlin's information-processing lens, this interplay confirms that both constructs share identical cognitive foundations, rooted in the richness of associative networks within long-term memory and the capacity for spreading activation. This empirical synergy carries profound pedagogical implications, demonstrating that teacher preparation programs do not require isolated curricular tracks for problem-solving and creativity. Instead, a singular, holistic pedagogical framework—leveraging problem-based learning and open-ended tasks—can concurrently elevate both core competencies required by future mathematics educators.

Based on these empirical insights, this study advances several strategic recommendations for reforming mathematics teacher education curricula. First, higher education institutions must systematically increase pre-service teachers' exposure to ill-defined problems to dismantle rigid mental sets and foster cognitive flexibility. Second, it is imperative to institutionalize structured self-verification exercises across advanced mathematics courses to explicitly train metacognitive monitoring and error-detection skills. Third, learning environments must be designed to be low-stakes and autonomy-supportive to actively mitigate math anxiety, thereby freeing up working memory capacity for higher-order creative exploration. Lastly, teacher preparation programs should deliberately embed structured problem-posing tasks that require backward planning, serving as a vital mechanism to cultivate both the mathematical originality and the pedagogical soundness of future educators.

[24] Evans et al., 'Non-Routine Mathematical Problem-Solving: Creativity, Engagement, and Intuition of STEM Tertiary Students'.
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